Space Weather Technical Forecast

Issued on Saturday, 06 May 2023 at 01:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1-R2 blackouts expected throughout with a slight chance of R3 Strong radio blackouts. G1-G2/Minor-Moderate Storm conditions expected 7-8 May with a chance of G3/Strong Storm conditions. Active electron fluence continuing, but likely to decline.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with two M-class flares observed from the region of AR3296. The peak flare was a M2.1 at 05/0801UTC from AR3296 (Dki/β). AR3297 (Eki/β) just to the south of AR3296 has not produced any significant flares, but contains a high level of magnetic flux and consequently a high flare risk. AR3293 also contains significant magnetic flux, but appears to have simplified magnetically. Ex-3288 just beyond the southeast limb remains active and produced a C9.5 flare at 05/2228UTC. The remaining regions are all small and benign, with no notable activity. A series of CMEs have left the Sun in the last 24 hours, with the most significant a full halo CME observed following the M2.1 flare. This is forecast to affect the Earth on 07 May in combination with a CME from 04 May.

Solar Wind / Geomagnetic Activity: The solar wind observed at L1 followed a declining trend and is now below 340km/s. Density has been around or slightly below average, with a slight upward trend, which may be indicative of the arrival of the broad CIR (co-rotating interaction region) ahead of the high speed stream from coronal hole 99. Total magnetic field strength has been weak, with the north-south component, Bz, varying weakly. Phi angle started negative (towards the Sun), but started to rotate into the positive sector from around 05/2000UTC. Geomagnetic activity was Quiet throughout.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, has been at background levels throughout. High energy electron flux (greater than 2MeV) as measured at GOES16, has remained at High levels, peaking at 5020pfu at 05/1645UTC. The 24-hour integrated fluence was at Active levels, with a steady trend. At 06/0000 UTC 2.54e8 integrated pfu was recorded.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected through the next four days, with a slight chance of Strong activity, mainly from the regions in the northeast of the visible disc. Further regions rotating from the farside could enhance any flare risk.

S**olar Wind / Geomagnetic Activity:** Two CMEs which left the Sun on 04 and 05 May respectively, are forecast to arrive concurrently on 07 May, with a risk of effects into 08 May. A number of partial halo CMEs are also forecast to combine with the two full halo CMEs, all with Earth-directed components. There is moderate confidence in the forecast arrival time of the CMEs. A high speed stream from coronal hole 99 is forecast to connect with Earth on 06 May, with estimated speeds of 500-600km/s, although this is with high uncertainty in the speed. Geomagnetic activity is expected to start Quiet to Unsettled, but with a chance of Active or G1/Minor Storms on 06 May due to the possible high speed stream connection. G1/Minor or G2/Moderate storms are expected on 07 May, with a chance of G3/Strong storms due to the forecast CME arrivals with impacts expected into 08 May. Residual and declining storming is then possible through to 09 May.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to persist at background with no solar radiation storms occurring.
High energy (greater than 2MeV) electron flux is expected to continue a diurnal oscillation, mainly above the High threshold, but with slightly declining peaks, but could decline sharply in any geomagnetic storming, although the effects of this are uncertain. The corresponding electron fluence is expected to continue above the Active threshold (1e8 integrated flux), but with a possibility of a declining trend, perhaps falling below the Active threshold (1e8 integrated pfu) by the end of the period.

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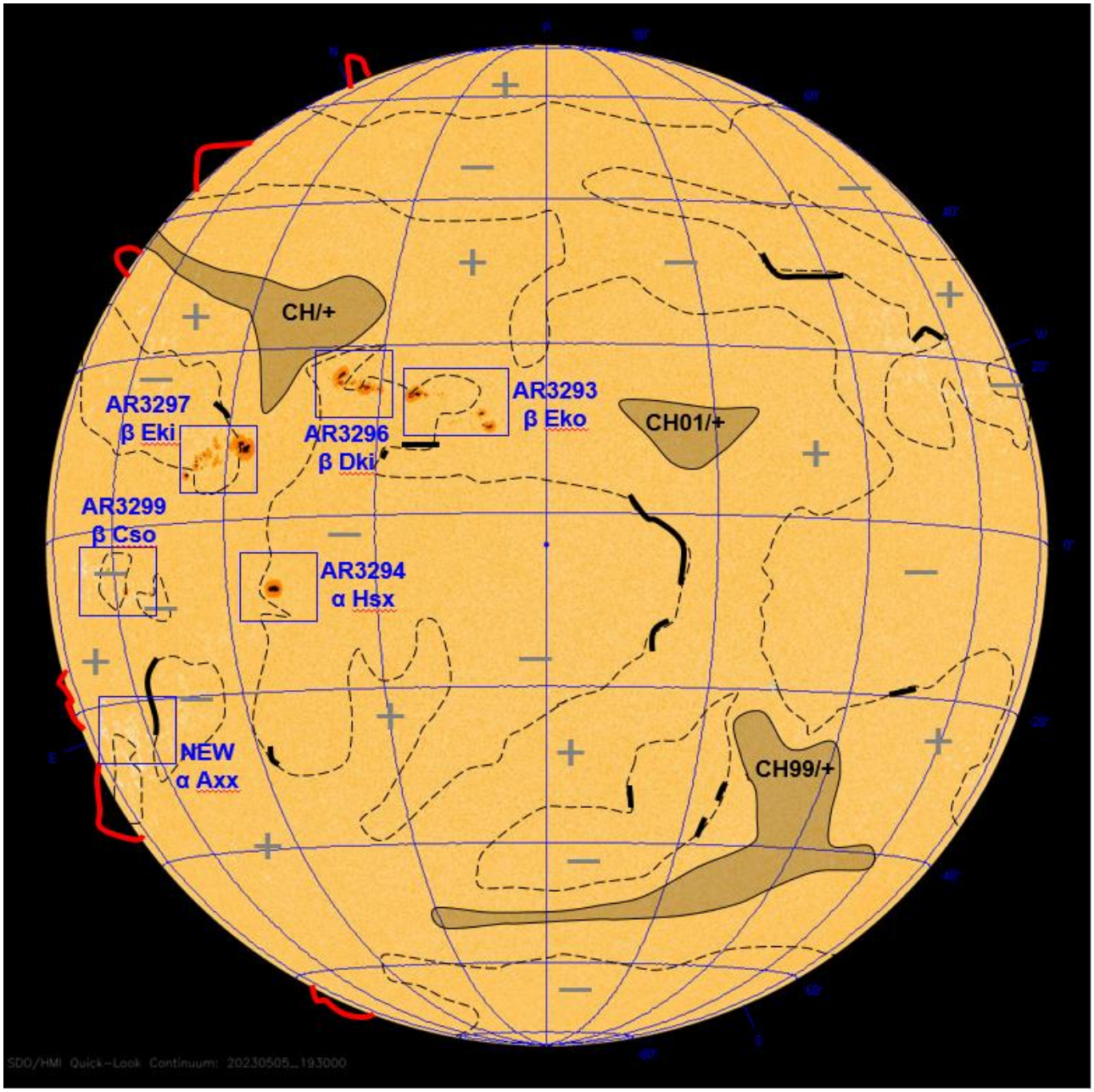
Figure 1. Solar Analysis Valid 05/2000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME, associated with an M3.9 flare from AR3296 on 04 May appears to have an Earth-directed component. A full halo CME also appears to be associated with this event and has been modelled as directly reaching the Earth. Both these CMEs are forecast to arrive on 07 May. A further full halo CME, in association with a combination of flares from AR3296 and AR3297 early on 05 May, have been forecast with speeds of 800-1000km/s and may merge with the earlier CMEs, and is also expected to arrive at Earth on 7 May. Due to the availability of satellite data, and the position of STEREO-A relative to Earth, these are considered as moderate confidence analysis of the CME parameters. Two significant partial halo CMEs, one linked to each eruption have also been modelled and are likely to combine with the two full halo CMEs.

A coronal hole high speed stream from coronal hole 99 is due to connect with Earth on 06 May. A broad increase in density was observed on STEREO-A data ahead of a connection to the high speed stream, with data at L1 suggesting that the Earth is now moving into the region of increased density. Speed data is still indeterminate, but is estimated to be in the range of 500-600km/s.

Geomagnetic activity is forecast to start mainly Quiet to Unsettled on 06 May, with Active or G1/Minor Storm intervals possible as the Earth connects with the coronal hole high speed stream. G1/Minor Storm or G2/Moderate Storms intervals are then expected during 07 May due to the forecast arrival of two concurrent full halo CMEs which left the Sun on 04 and 05 May. Dependent on polarity of the CMEs, there is a chance of G3/Strong Storm conditions. Similar conditions are then possible on 08 May due to uncertainty in the precise timing of the CME arrivals. Residual effects from the CME arrivals may then persist into 09 May, but with lower confidence on storm levels.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	70	70	50
Strong	G3	No	1	20	20	5
Severe	G4	No	1	1	3	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/1555	Full	AR3293	NE quadrant	550	07/1400UTC +/- 8 hours	May merge with second full halo
05/1117	Full	AR3296 and/or AR3297	NE quadrant	950	07/1400UTC +/- 8 hours	May catch and merge with previous CME

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Figure 2: MOSWOC Enlil showing potential arrival time of the two full halo CMEs.

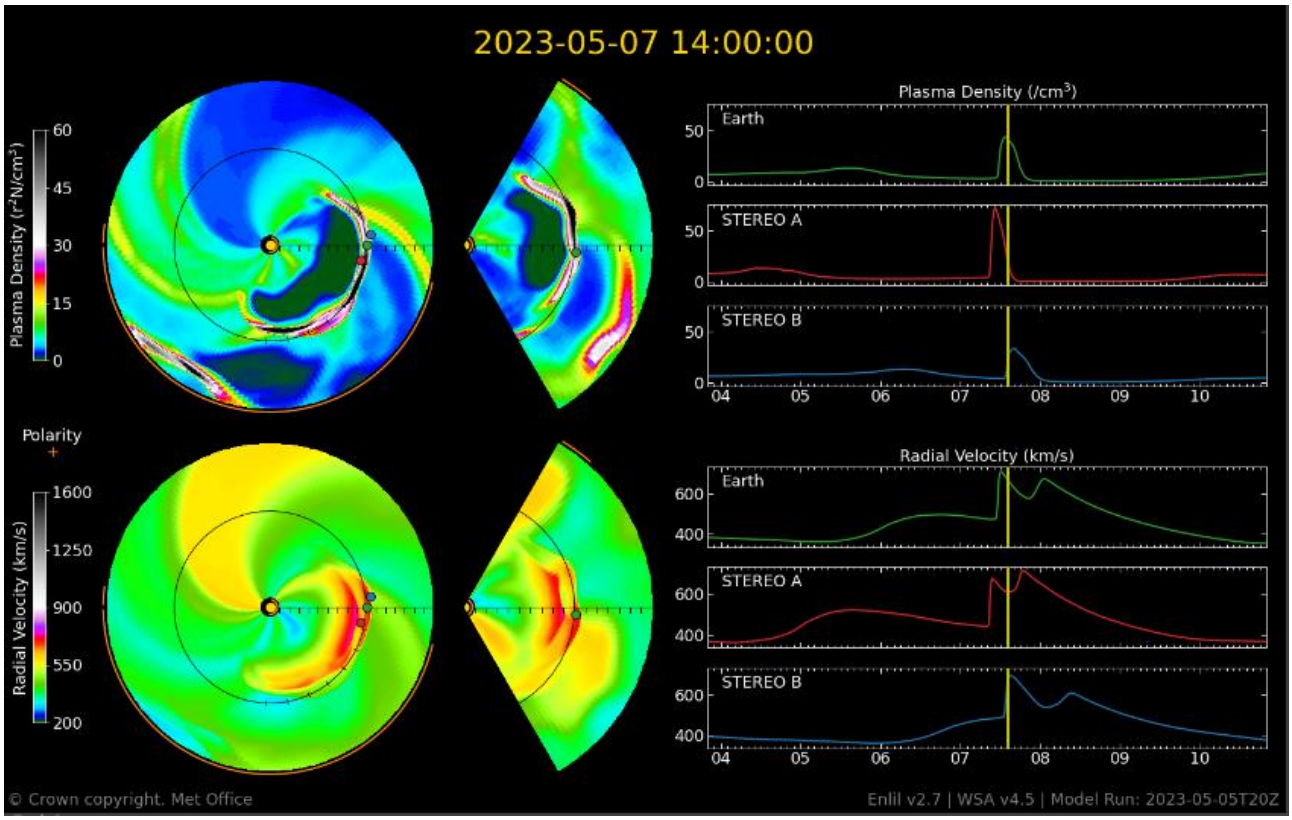
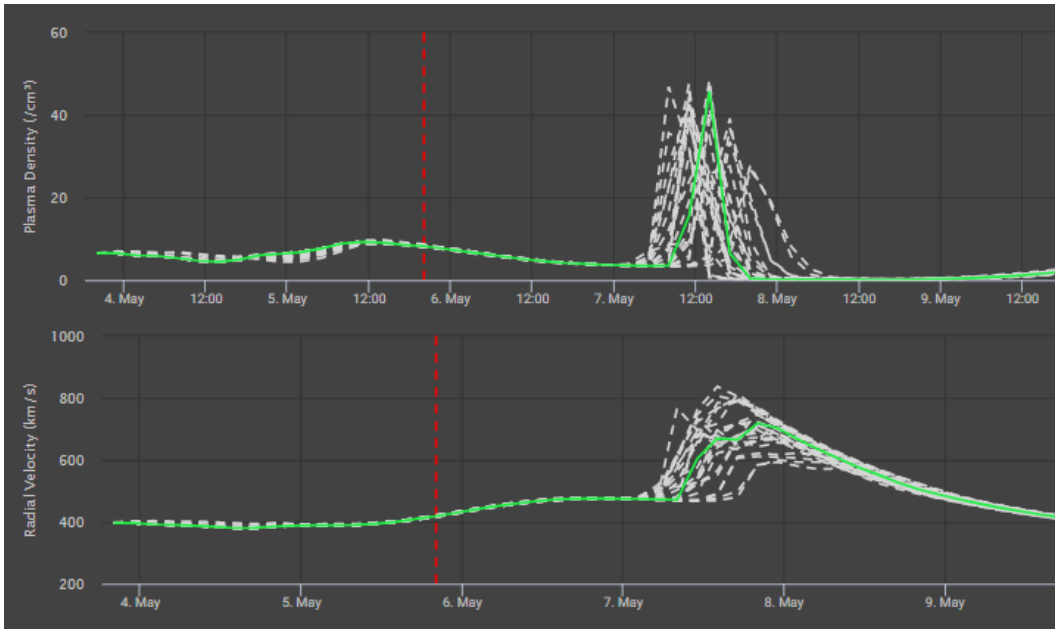


Figure 3: Enlil ensemble showing the potential range in arrival times.



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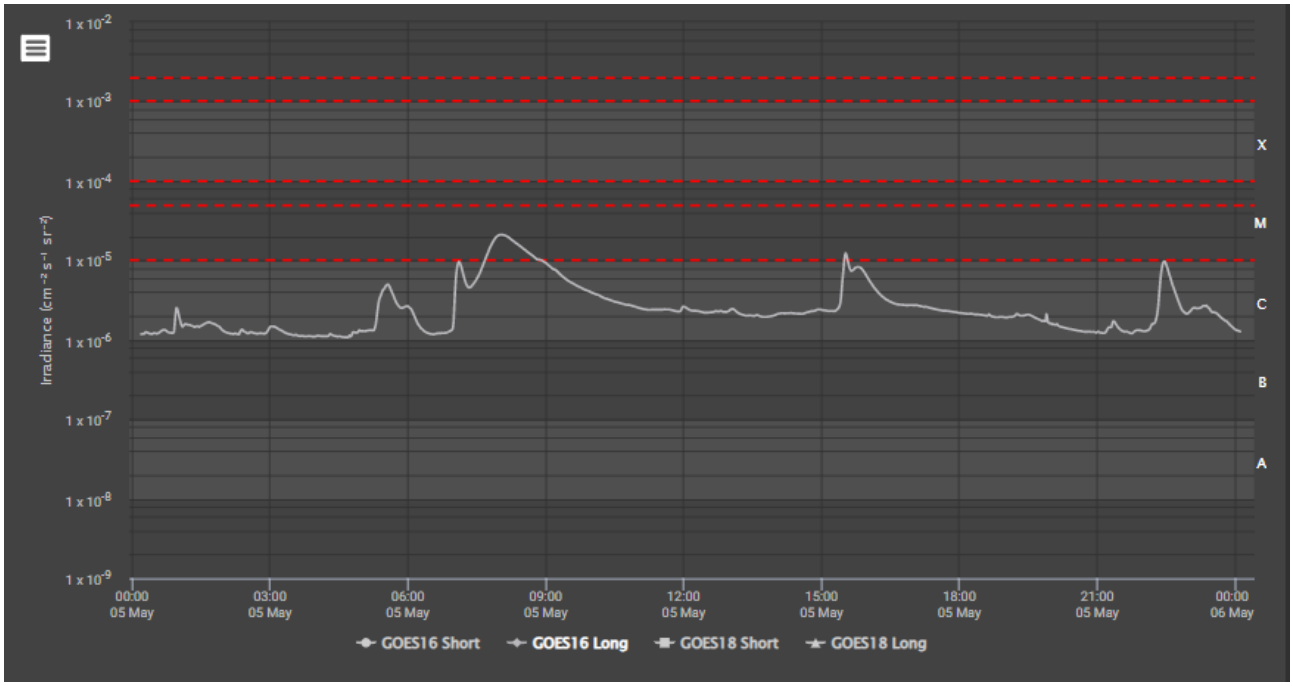
Radio Blackouts - X-Ray Flares:
There are six sunspot regions on the visible disc. AR3296 (Dkiβ) and AR3297 (Eki/β) in the northeast quadrant present the highest flare risk and are the most magnetically complex regions. These two regions were associated with an M-class flare and full halo CME on 05 May, so still present a significant risk of activity. AR3293 (Eko/β), following activity on 04 May, appears to have simplified dramatically, with the central delta spots fading but is still large and complex.

Ex-AR3288 was a complex region on the southeast limb, but is still producing significant flares from beyond the limb. The remaining regions are all simple or evolving slowly. Further significant spots could rotate from the farside during the period, enhancing any flare risk.

Moderate flare activity is expected through the next four days, with a slight chance of Strong flares, mainly from AR3296 or AR3297.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 4: GOES 16 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux as observed by GOES-16 is most likely to persist at background levels. However, count rates may increase with any significant flares that occur, mainly from AR3288 that has just reached the west limb. From 6 May the risk of radiation storms diminishes slightly as AR3288 rotates further beyond the west limb. Other regions in the east present an increasing, but as yet only slight, risk of Earth-directed radiation storms as they rotate across the northeast quadrant.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux levels are forecast to continue at high levels through 06 May, but then any confidence decreases rapidly. This is firstly due to the onset of a high speed stream, expected during 06 May, which could introduce further electrons into the belts, and with an estimated speed of 400-500km/s is unlikely to significantly distort the belts. The second source of uncertainty is due to the forecast arrival of two CMEs on 07 May and possible associated geomagnetic storms. There is a likelihood that electron counts could remain above the threshold after brief dips, as the CME fronts first displace the radiations belts from GEO orbit, before injecting further electrons into the radiation belts.

Electron fluence values, which are currently above the Active threshold on a steady trend, may see dips towards to the 1e8 integrated pfu level in response to marked decreases in the electron counts. Uncertainty the falls sharply through the period, with a 50% risk of 08 and 09 May indicative of this uncertainty.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	60	50	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 5: GOES16 electron flux and MOSWOC REFM model. The forecast shown in the model is subject to high uncertainty.

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